Grass assemblages and diversity of conservation areas on the coastal plain south of Maputo Bay, Mozambique

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Keywords: dunes, forest, grasses, grassland, Maputaland, Mozambique, Poaceae, woodland

ABSTRACT

A floristic analysis of the grass species assemblages of the Licuati Forest and Maputo Elephant Reserves south of Maputo Bay, Mozambique, is presented. Sampling of grass data was undertaken in six previously described, major vegetation types. TWINSPLAN divisions distinguished grass assemblages that are characteristic for these major vegetation types of the study area. The results were supported by an Indirect Gradient Analysis. Further TWINSPLAN divisions of a larger Maputaland data set indicated a floristic relationship between grass assemblages of similar major vegetation types in the study area and South Africa. This relationship was supported by high similarity values (> 65%), obtained with Sorensen’s Coefficient. The coefficient also indicated varying degrees of similarity between grass assemblages of different major vegetation types within the study area. A rich diversity of 115 grass species and infraspecific taxa was recorded for the study area. The Chloridoideae and Panicoideae dominate the grass diversity and the genera with the most species include Eragrostis, Panicum and Digitaria. Most grass species in the study area are perennials and have a tufted growth form, but this varies considerably between vegetation types.

INTRODUCTION

Despite the importance of the Poaceae to both subsistence and commercial agriculture (Myre 1971; Tainton et al. 1990; Kobisi & Kose 2003), some areas still remain poorly studied and documented. One particular area is the coastal plain of Mozambique south of Maputo Bay. Although Myre (1964) and De Boer et al. (2000) provided a comprehensive account of the vegetation south of Maputo Bay in Mozambique, the descriptions of the grass layer contained limited taxonomic and floristic information.

In this paper the grass diversity of the coastal plain south of Maputo Bay is revisited to investigate the following hypotheses based on current knowledge: 1, different grass assemblages characterize the major vegetation types of the study area; 2, a floristic relationship exists between grass assemblages of different major vegetation types within the study area; 3, there is a floristic relationship between grass assemblages of the study area and similar vegetation types in South Africa; 4, species that form the grass assemblage for a major vegetation type are characterized by certain life/growth forms; 5, dominance of different Poaceae subfamilies in the study area correspond with predictions made previously; and 6, there is a rich diversity of grasses in the study area.

STUDY AREA

The study area comprises the Maputo Elephant Reserve and Licuati Forest Reserve on the Maputaland coastal plain, south of Maputo Bay in Mozambique (Figure 1). Maputaland is an important centre of plant endemism and diversity of Mozambique, South Africa and Swaziland (Van Wyk & Smith 2001), defined as the biogeographical area bounded by the Inkomati-Limpopo River in the north, Indian Ocean in the east, foothills of the Lebombo Mountains in the west and St Lucia estuary in the south.

The topography comprises high, linear, north-south oriented dune cordons along the inland margin of the coast. The youngest of these dunes are probably 10 000–30 000 years old, making them in geological terms some of the youngest formations in southern Africa (Botha 1997). These high dune cordons mark a succession of marine regressions that deposited these sediments. Marine siltstone underlies these sediment deposits and in turn, the sediment deposits underlie the dune sand deposits currently defining the surface relief in this area.

Maputaland lies within a transitional zone between the tropics and subtropical coastal conditions to the south (Bruton & Cooper 1980), with warm to hot summers (mean of 27°C in January) and cool to warm winters with no frost (mean of 16°C in July). Mean relative air humidity is high along the coast, namely 55% in August and 90% in February. Summers are wetter than winters, although rain is received throughout the year. Mean annual rainfall is higher along the coast (1 100 mm/year) and declines progressively inland (600 mm/year). Morning mist is common in the dry season.

The study area comprises the major terrestrial vegetation types recognized and defined for this floristic region by Myre (1964), De Boer et al. (2000) and Matthews et al. (1999, 2001), namely Coastal Woodland, Dune Forest, Licuati (Sand) Forest, Primary Dunes, Reed Beds and Woody Grassland.

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METHODS

Sampling sites were randomly selected using topographic maps and aerial photographs. Plots were placed in vegetation types conforming to the descriptions of Matthews et al. (1999, 2001), avoiding the edges of these and refraining from sampling in disturbed areas. Presence/absence of diagnostic woody species was used to identify vegetation types in the field. A vegetation type is a composition of species that recurs in a region as a result of specific combinations of environmental factors (Barbour et al. 1999). Reed Beds could not be sampled adequately due to high water tables. However, wetlands that feed into the Reed Beds were sampled, and these are referred to as Hygrophilous Grassland for the purpose of this study.

Twenty-one sites were sampled at the beginning of summer 2001, the peak flowering season for grasses. At each site all the grass species in a $20 \times 20$ m grid were collected and identified. Scientific names conform to Fish (2003). Voucher specimens are listed in a checklist (Appendix 1) and housed at the Maputo Herbarium (LMA), with duplicates in the Luanda Herbarium (LUAI), Natal Herbarium (NH), Pretoria National Herbarium (PRE) and University of Zambia Herbarium (UZL). The LMA collection was consulted to identify sterile specimens and to locate fertile voucher specimens for these species. If none were found, sterile specimens were provisionally identified, but listed without voucher specimens in the checklist.

A floristic classification of grass data for the Licuati Forest and Maputo Elephant Reserves was obtained by the application of Two-Way Indicator Species Analysis (TWINSPAN) (Hill 1979a). The multivariate analysis divided the data set, comprising all collected grass species and their presence/absence data per plot, into nodes. In MEGATAB (Hennekens 1996) the resultant classification was summarized in a synoptic table to reflect percentage occurrence of each species per node (major vegetation type) and refined with Braun-Blanquet procedures to group species in assemblages. Detrended Correspondence Analysis (DECORANA) (Hill 1979b) was applied to the data set to illustrate vegetation gradients and floristic relationships.

A second data set containing grass species presence/absence data from the study area was merged with data from studies conducted in Sileza Nature Reserve (Matthews et al. 1999) and Tembe Elephant Park (Matthews et al. 2001). Vegetation types from these conservancies in South Africa were chosen for comparison because of their similar grass flora, status as pristine environments, proximity to the study area, and formal classification and description as representative of northem Maputaland. The TWINSPAN divisions depicting the floristic relationship are illustrated in a dendrogram (Figure 2).
The species richness of grasses was calculated as the number of species per major vegetation type (homogeneous unit) in the study area (Whittaker 1978). Rare and threatened species were identified as either endemic (Van Wyk 1996) and/or Red Data List (Izidine & Bandeira 2002). Character species were defined as species that are relatively restricted to specific vegetation types (Westhoff & Van der Maarel 1978). Recognition as an introduced alien species was based on Fish (2003). Life cycles (annual or perennial) and growth form (tufted, rhizomatous and/or stoloniferous) of each species followed Gibbs Russell et al. (1990). Sorenson’s Index (Mueller-Dombois & Ellenberg 1974) was used to determine the beta diversity between the vegetation types of the study area and between different reserves in Maputaland.

Floristic diversity of the Poaceae subfamilies/tribes, and the distribution types of these taxonomic units within the different vegetation types were presented in tables to interpret and compare current patterns of grass diversity with what was previously predicted for southern Africa (Gibbs Russell 1986, 1988).

RESULTS AND DISCUSSION

The resultant hierarchical division of the sample plots from the TWINSPLAN analysis (Table 1) resulted in the classification of distinct grass assemblages associated with six major terrestrial vegetation types of the Maputaland coastal plain in Mozambique, namely Coastal Woodland, Dune Forest, Hygrophilous Grassland, Licuati Forest, Primary Dunes and Woody Grassland. The ordination clusters (Figure 3) obtained for the first and second axes tended to substantiate the groups identified in the TWINSPLAN classification. A TWINSPLAN division of the Mozambican grass data merged with sample plots from South Africa resulted in a hierarchy of assemblages that confirms that a floristic link exists between these different parts of Maputaland (Figure 2).

Grass assemblages

1. Grass assemblage of Primary Dunes
   Locality: Maputo Elephant Reserve

   This assemblage is restricted to the upper reaches of beaches, bordering on the seaward side of primary dunes. Grasses are mostly pioneers and are not only associated with the unstable seashore dunes, but also occur further inland along freshwater and saline marshes, and in disturbed places such as road reserves. Grasses of the assemblage prefer light shade, but tolerate full sun.

   Character species for this grass assemblage are given in species group A (Table 1). The assemblage is species poor and although predominantly characterized by perennials, has the highest proportion of annuals (36%) in the study area. It also has the highest proportion of grass species with a stoloniferous growth form (35%). One naturalized alien grass, *Cenchrus brownii*, was recorded. Taxonomically the vegetation type is unique in that it is not characterized by the Paniceae (Panicoideae) as in the grass assemblages of the other vegetation types (Table 2), but is dominated by the Eragrostideae (Chloridoideae). The community is floristically most related to Hygrophilous Grassland (Sorenson Coefficient = 15%; Table 1) (Figure 3).

2. Grass assemblage of Hygrophilous Grassland
   Locality: Maputo Elephant Reserve

   Hygrophilous Grassland represents a vegetation type of open grassland on seasonally wet, sandy or clay soils. These seasonally wet areas may occur as inter-dune
Character species for the grass assemblage are given in species group B (Table 1). This grass assemblage is species rich (56 taxa) and tufted perennials dominate. It also has the highest proportion of rhizomatous taxa (36%). There are 15 character grass species, which is the most for any of the major vegetation types. This is the only grass assemblage in the study area characterized by representatives from the Arundineae, Aveneae and Oryzeae (Table 2). Floristically this assemblage is most related to Woody Grassland and Dune Forest (Sorenson Coefficient = 56%, 58% and 56% respectively; Table 1) (Figure 3). Of all the grass assemblages in the study area, it has the lowest similarity in grass species composition when compared with similar vegetation further south in South Africa (Sorenson Coefficient = 63%; Table 3) (Figure 2).

4. Grass assemblage of Dune Forest
Locality: Maputo Elephant Reserve

Forests mainly occur on well-established secondary dunes and further inland. Soils are moist, deep and sandy. Forest trees have a higher diversity of creepers and understorey vegetation than the vegetation of surrounding areas. Grass species of Dune Forest prefer semi-shade and are especially common along forest margins, riverbanks, and partially disturbed and overgrazed areas.

Seven character species for this grass assemblage are given in species group F (Table 1). This grass assemblage is the most species rich (57 taxa). It is characterized by tufted perennials, has the highest number of recorded rare grass species (5) and taxonomically it is dominated by the Panicoideae, although the Eragrostideae, a tribe of the Chloridoideae, supports the highest diversity (Table 2). Along the coast, Dune Forest tends to

3. Grass assemblage of Woody Grassland
Locality: Maputo Elephant Reserve

Extensive grasslands occur along the coast south of Maputo Bay and is characterized by deep, well-drained sandy to loam soils and an undulating topography (dunes and floodplains). This grassland type is endemic to Maputaland and is dominated by geoxyl suffrutesces which are dwarf woody plants with annual or short-lived shoots sprouting from woody, perennial underground axes. Woody Grassland is not as rich in grass species as the Hygrophilous Grassland.

Character species of the grass assemblage are given in species group D (Table 1). A low number of four character species were recorded, because grassland represents a transition between other major vegetation types. This assemblage is characterized by tufted, perennial species. The Andropogoneae (Panicoideae) dominate the assemblage (Table 2). One rare grass species, namely the Maputaland endemic Trichoneura schlechteri, was recorded. Floristically it is most related to Dune Forest, Coastal Woodland and Hygrophilous Grassland (Sorenson Coefficient = 62%, 58% and 56% respectively; Table 1) (Figure 3). Of all the grass assemblages in the study area, it has the lowest similarity in grass species composition when compared with similar vegetation further south in South Africa (Sorenson Coefficient = 63%; Table 3) (Figure 2).
<table>
<thead>
<tr>
<th>Nodum</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample sites</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

**Species Group A:** Diagnostic grass assemblage of Primary Dunes (PD)

- Dactyloctenium australe *p s* 100
- Digitaria ciliaris *a t* 100
- Stenotaphrum dimidiatum *p s* 100
- *Cenchrus brownii* *a t* 50
- Dactyloctenium argenteum *a t s* 50

**Species Group B:** Diagnostic grass assemblage of Hygrophilous Grassland (HG)

- Hemarthria altissima *p r s* 100
- *C. brownii* *a t* 50
- Dactyloctenium aegyptium *a t s* 50

**Species Group C:** Diagnostic grass assemblage of Woody Grassland (WG)

- Eragrostis inamoena *p t r* 100 70
- *Sporobolus virginicus* *p s r* 50 50

**Species Group D:** Diagnostic grass assemblage of Dune Forest (DF)

- Digitaria argyrothricha *p t r* 80
- *Panicum pleianthum* *p t* 60

**Species Group E:** Diagnostic grass assemblage of Coastal Woodland (CW)

- *Coix lacryma-jobi* *a t* 25
- *Cenchrus ciliaris* *a t* 25
- *Chloris virgata* *a t* 25
- *Enneapogon scoparius* *a t* 25
- *Eragrostis sarmentosa* *p t r* 25
TABLE 1.—Diagnostic grass assemblages of the major vegetation types of the Maputaland coastal plain south of Maputo Bay in Mozambique.

<table>
<thead>
<tr>
<th>Nodum</th>
<th>Vegetation type</th>
<th>Sample sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PD</td>
<td>HG</td>
</tr>
<tr>
<td>Species Group J (cont.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eriochloa meyeriana subsp. meyeriana p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicum coloratum var. coloratum p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setaria incrassata p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum bicolor subsp. arundinaceum p t</td>
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<td></td>
</tr>
<tr>
<td>Species Group K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichoneura grandiglumis p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eustachys paspaloides p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sporobolus sanguineus p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andropogon schirensis p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cymbopogon excavatus p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cymbopogon nardus p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melinis repens subsp. repens a t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species Group L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eragrostis heteromera p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diheteropogon amplitudes p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Themeda triandra p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setaria spiculata var. sericea p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bewisia biflora p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pogonarthria squarrosa p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichopogon spicatus p t</td>
<td></td>
<td></td>
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<tr>
<td>Saccoilepis carvata p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urelytrum agropyroides p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urochloa mosambicensis p s t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertelium dissoluvelix p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andropogon gowanii var. polycladus p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloris gowanii p s t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species Group M: Diagnostic grass assemblage of Licuati Forest (LF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Megastachya macrantha p s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digitaria longiflora p s t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ehrhartia erecta var. natalensis p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eragrostis gummiflua p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oplismenus hirtellus p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tristachya nodiglumis p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melinis repens subsp. grandiflora a t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species Group N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eragrostis superba p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eragrostis pallens p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species Group O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicum deustum p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sporobolus fimbriatus p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brachiaria chusqueoides a t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>**Eragrostis moggi var. moggi p t s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicum heterostachium a t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>**Alloteropsis papillosa p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicum latifolium a t s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eleusine coracana subsp. africana a t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eleusine indica a s t</td>
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</tr>
<tr>
<td>Species Group P</td>
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<td></td>
</tr>
<tr>
<td>Aristida stipitata subsp. graciliflora p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>**Trichoneura schlechteri p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species Group Q</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicum maximum p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aristida congesta subsp. congesta p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perotis patens p t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digitaria esculenta p s t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicum kalaharense p r t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage perennial/annual</td>
<td>64 / 36</td>
<td>91 / 9</td>
</tr>
<tr>
<td>Percentage tufted/rhizomatous/stoloniferous</td>
<td>35 / 30 / 35</td>
<td>51 / 36 / 13</td>
</tr>
<tr>
<td>Total no. species</td>
<td>11</td>
<td>56</td>
</tr>
<tr>
<td>Restricted to community (character species)</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>*No. naturalized aliens</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>**No. rare and threatened species</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sorensen Coefficient (%):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PD</td>
<td>100</td>
<td>15</td>
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<tr>
<td>HG</td>
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<td>WG</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td>DF</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td>CW</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>LF</td>
<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>
be continuous, but inland it forms a mosaic with other vegetation types. Its grass assemblage therefore shows a strong floristic link with Woody Grassland, Coastal Woodland, Hygrophilous Grassland, and to a lesser extent Licuati Forest (Sorenson Coefficient = 62%, 58% and 39% respectively; Table 1) (Figure 3). It also shows a high similarity in grass species composition when compared with plots from Maputaland Dune Forest in South Africa (Sorenson Coefficient = 67%; Table 3) (Figure 2).

5. Grass assemblage of Coastal Woodland
Locality: Maputo Elephant Reserve and Licuati Forest Reserve

Savanna covers extensive areas along the coast south of Maputo Bay and stretches westwards to the foothills of the Lebombo Mountains. The vegetation type occurs on sandy soils in drier habitats with a deeper water table. The grass assemblage forms a dense herbaceous layer and is associated with light shade or full sunlight and occurs in a wide range of habitats including floodplains, dune crests, drainage lines, transition zones and disturbed areas.

Nine character species were recorded for this assemblage and are given in species group J (Table 1). Tufted perennials typically dominate this grass assemblage. Two rare species were recorded and one naturalized alien grass, Coix lacryma-jobi, has colonized this assemblage. This is the only grass assemblage that contains a member of the Pappophoreae and is dominated by the Panicoideae (Table 2). Dune Forest forms localized patches within Coastal Woodland, and in turn, Coastal Woodland within Woody Grassland. Hence, its grass assemblage shows a strong floristic link with Dune Forest and Woody Grassland, and to a lesser extent with Licuati Forest on which it borders (Sorenson Coefficient = 62%, 58% and 41% respectively; Table 1) (Figure 3). The assemblage is similar to that of corresponding Maputaland woodlands in South Africa (Sorenson Coefficient = 67%; Table 3) (Figure 2).

6. Grass assemblage of Licuati Forest
Locality: Licuati Forest Reserve

This vegetation type is endemic to Maputaland and has many rare plant species. It is restricted to the ancient coastal dunes of Maputaland, and drier (600 mm per annum) conditions than most of the other coastal forest types in southern Africa. This grass assemblage prefers moister habitats in shady places and is common along forest margins. Based on vegetation structure and species composition the forests of ancient dunes in Maputaland can be divided into Licuati Forest and Licuati Thicket (Izidine et al. 2003).

Character species of the grass assemblage are given in species group M (Table 1). Although it is a forest system and tufted perennials dominate the grass assemblage, this vegetation type has a high proportion (24%) of annual species. The assemblage is species poor, but a high proportion of three rare species are recorded for the assemblage. This is the only vegetation type in the study area with representatives from the Arundinellaceae, Centothecoideae and Ehrharteae, and the only one without a representative of the Andropogoneae (Table 2). This grass assemblage is related to Coastal Woodland and Dune Forest as a result of similar microhabitats (Sorenson Coefficient = 41% and 39% respectively; Table 1) (Figure 3). It also shows a high similarity in grass species composition when compared with plots from Maputaland sand forest in South Africa (Sorenson Coefficient = 71%; Table 3) (Figure 2).

Floristic analysis

In a provisional checklist compiled from available literature for the two Maputaland reserves in Mozambique, the Poaceae numbered 52 species/infraspecific taxa and 36 genera. Currently, with 95% of the collected specimens identified, the updated checklist (Appendix 1) contains 115 species/infraspecific taxa and 56 genera. However, 15 species previously recorded were not collected again. Most of these taxa are either locally rare (e.g. Panicum genuflexum and Triraphis andropogoides) or wetland species (e.g. Leersia hexandra and

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**TABLE 2.—Numbers of species of Poaceae subfamilies/tribes recorded within major vegetation types of Maputaland, south of Maputo Bay**

<table>
<thead>
<tr>
<th>Subfamily/Tribe</th>
<th>PD</th>
<th>HG</th>
<th>WG</th>
<th>DF</th>
<th>CW</th>
<th>LF</th>
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<tbody>
<tr>
<td>Bambusoideae</td>
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<td>1</td>
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<td>Oryzeae</td>
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</tr>
<tr>
<td>Centothecoideae</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Pooideae</td>
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</tr>
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</tr>
<tr>
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<td>4</td>
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<td>2</td>
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<td>2</td>
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<tr>
<td>Arundinelleae</td>
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<td>1</td>
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<tr>
<td>Chloridoideae</td>
<td>7</td>
<td>18</td>
<td>14</td>
<td>24</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Paniceae</td>
<td>3</td>
<td>17</td>
<td>10</td>
<td>18</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>Panicoideae</td>
<td>4</td>
<td>32</td>
<td>23</td>
<td>30</td>
<td>26</td>
<td>12</td>
</tr>
<tr>
<td>Andropogoneae</td>
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<td>15</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

* CW, Coastal Woodland; DF, Dune Forest; HG, Hygrophilous Grassland; LF, Licuati Forest; PD, Primary Dunes; WG, Woody Grassland

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**TABLE 3.—Similarity indices of grass assemblages shared between major Maputaland vegetation types in Mozambique (Moz) and South Africa (RSA)**

<table>
<thead>
<tr>
<th>Vegetation type*</th>
<th>Total species (Moz)</th>
<th>Total species (RSA)</th>
<th>Shared between Moz and RSA</th>
<th>Sorenson Index (S%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HG</td>
<td>37</td>
<td>37</td>
<td>28</td>
<td>76</td>
</tr>
<tr>
<td>WG</td>
<td>22</td>
<td>32</td>
<td>17</td>
<td>63</td>
</tr>
<tr>
<td>DF</td>
<td>42</td>
<td>34</td>
<td>26</td>
<td>71</td>
</tr>
<tr>
<td>CW</td>
<td>31</td>
<td>32</td>
<td>21</td>
<td>67</td>
</tr>
<tr>
<td>LF</td>
<td>26</td>
<td>19</td>
<td>16</td>
<td>71</td>
</tr>
</tbody>
</table>

* CW, Coastal Woodland; DF, Dune Forest; HG, Hygrophilous Grassland; LF, Licuati Forest; WG, Woody Grassland
Dinebra retroflexa var. condensata), for which high water tables made their localized habitats inaccessible.

In the study area the most commonly represented subfamilies are the Panicoideae with 66 species/infraspecific taxa (accounting for 57% of the total checklist) and Chloridoideae with 39 taxa (34%) (Table 4). Together they account for 91% of the species in the checklist. The tribes with the most species are the Paniceae (41 taxa), Eragrostideae (32 taxa) and Andropogoneae (24 taxa) (Table 4). The genera with the most species are Eragrostis (12), Panicum (10), Digitaria (8) and Sporobolus (6). Andropogon, Brachiaria and Dactyloctenium are represented by four species each.

Interesting species were recorded, such as Panicum kalaharense (usually associated with much drier areas on Kalahari sands) and Monocymbium ceresiforme (usually associated with much higher altitudes on mountains). Many grass species of direct significance for conservation initiatives, reserve management and sustainable utilization were also recorded:

1. three Maputaland endemic grasses belonging to the Eragrostideae (Van Wyk 1996). Brachychloa schiemanniana occurs in Dune Forest, Eragrostis moggii var. moggii is associated with Licuati Forest and Dune Forest, and Trichonemia schlechteri is found in Coastal Woodlands, Dune Forest, Licuati Forest and Woody Grassland. Brachychloa fragilis was not recorded, although it is a typical endemic associated with deep sands in South Africa;

2. three alien grasses belonging to the Panicoideae. As is the case in many Centres of Endemism in the world (Stohlgren et al. 1999), alien taxa have also invaded Maputaland. Cenchrus brownii has invaded vegetation of Primary Dunes and Coix lacryma-jobi and Digitaria didactyla occurs in Coastal Woodland in the vicinity of villages;

3. two Red Data List grass species: Panicum pleianthum from Dune Forest which is assessed as Low Risk (Izidine & Bandeira 2002), and Allotropis papillosa from Dune Forest, Coastal Woodland and Licuati Forest which is assessed as Insufficiently Known (Hilton-Taylor 1996). Both species are locally common and known to occur as far north as Kenya and Tanzania.

4. eight grasses that are important for rural livelihoods. Some species are used as important components to build huts: Phragmites australis for the walls and Cymbopogon excavatus, Imperata cylindrica and Hypertherelia dissolata to thatch the roof (Mangue 1999). Dactyloctenium giganteum, Eleusine coracana subsp. africana, Echinocloa pyramidalis and Sorghum bicolor subsp. arundinaceum are used as indigenous grass cereals (Scudder 1971).

Correlation analyses of the floristic data did not reveal any meaningful relationships. The only significant positive correlation ($n = 6; r = 0.827; P = 0.04$) was obtained between the number of rare/endemic grass species and the number of annual grass species per vegetation type. Forests/woodlands have higher numbers of rare/endemic and annual grass species than grasslands.

**Distribution patterns**

All known distributions of the six grass subfamilies extend into southern Mozambique. The diversity of the Chloridoideae and the Panicoideae in the study area was expected and subsequently were the best represented in the major vegetation types. The dominance of the Panicoideae (both C4 and C3 grasses) in the terrestrial vegetation types coincides with the centre of diversity of the subfamily in mesic summer rainfall regions (Gibbs Russell 1986). However, its diversity was much lower than would be expected (19% instead of the predicted 46–60%) (Table 4). The diversity of species of the Chloridoideae (mainly C4 aspartate producers) was within the expected range of 16–30% (17% of the subfamily’s species was recorded) (Table 4), as this subfamily’s centre of diversity is mainly situated further north in arid summer rainfall regions (Gibbs Russell 1986). Chloridoideae dominated the grass assemblage of the Primary Dunes. The species diversity of the other four subfamilies was as predicted by Gibbs Russell (1988).
Bothalia 34,1 (2004)

69

noideae is dominant in Hygrophilous Grassland and the remaining three subfamilies are associated mainly with Hygrophilous Grassland and Licuati Forest.

The tribes, Eragrostideae (C₄ aspartate), Paniceae (both C₃ and C₄) and Andropogoneae (C₄ malate) dominate the grass assemblages of the major vegetation types, probably due to specific regional climatic conditions, such as high temperatures at the local scale, which favour these C₄ groups to successfully colonize specific habitats. Eragrostideae dominate the grass assemblages of Dune Forest and Primary Dunes, the Paniceae dominate in Coastal Woodland, Hygrophilous Grassland and Licuati Forest, and the Andropogoneae in Woody Grassland (Table 2). The Aristideae and Cynodonteae are found in nearly all the vegetation types, but are restricted to a maximum of four species per vegetation type. This is low when compared to the maximum of 21, 18 and 15 species respectively recorded for the three dominant tribes. The remaining seven tribes are restricted to single vegetation types. Three of these tribes are associated with Licuati Forest, two with Hygrophilous Grassland and one with Coastal Woodland.

CONCLUSIONS

It is evident from the analysis of the grass diversity on the coastal plain of southern Mozambique that a specific grass flora is present and that six species assemblages are associated with and characteristic of certain major vegetation types of the coastal plain.

The grass assemblage of Dune Forest was qualitatively the most similar and central to the grass assemblages of the other vegetation types south of Maputo Bay. Primary Dunes have the most floristically unrelated grass assemblage to other vegetation types.

Similarity in grass assemblage composition was more than 60% for each vegetation type shared between reserves in Mozambique and South Africa. This relationship with areas further south links the grass assemblages to the Maputaland floristic region.

Grasses of the study area are mostly perennial. Woody Grassland has the highest proportion of perennial species and Primary Dunes the highest proportion of annuals. Tufted grasses are the most common growth form with the highest proportions in Licuati Forest and Coastal Woodland.

Chloridoideae and Panicoideae dominate the grass composition in the study area. The tribes Paniceae, Eragrostideae and Andropogoneae are represented most and Eragrostis, Panicum and Digitaria are the largest genera of this part of Maputaland.

The coastal plain south of Maputo Bay has a grass diversity of 115 species and infraspecific taxa. Dune Forest and Hygrophilous Grassland have the richest grass diversity. Dune Forest has the most rare and endemic grass species and Hygrophilous Grassland the most character species.

ACKNOWLEDGEMENTS

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REFERENCES


Bothalia 34,1 (2004)


APPENDIX 1.—Checklist of grasses recorded for the major vegetation types of the Maputo Elephant and Luciati Forest Reserves

Arrangement and classification follow Clayton & Renvoize (1986) and author citations follow Brummitt & Powell (1992). Species names follow Fish (2003) and general practice at Maputo Herbarium (LMA). All specimens are housed at LMA, with duplicates specified for the herbaria of Luanda (LUAI), Natal (NH), Pretoria (PRE) and University of Zambia (UZL). Naturalized alien species are marked with an asterisk*, Maputaland endemic species with **, and Red Data List species with ***. Abbreviations for collectors’ names: Brummitt & De Koning, U 61 (NH).

superba Peyr., N 362 (UZL), U 101 (NH).

Pogonarthria squarrosa (Roem. & Schult.) Pilg., S 2173 (PRE), U 53 (NH).

Sporobolus africana (Poir.) Robyns & Tournay, S 2140 (PRE), U 63 (NH).

fimbriatus (Trin.) Nees, S 2176 (PRE), U 89 (NH).

sanguineus Rendle, S 2186 (PRE), U 100 (NH).

subtilis Kunth, N 354 (UZL), U 81 (NH).

subulatus Hack., S 2123 (PRE).

virginicus (L.) Kunth, S 2106 (PRE), U 59 (NH).

Trichoneura grandiglumis (Nees) Ekman, S 2161 (PRE), U 67 (NH).

**schlechteri Ekman, S 2170 (PRE), U 86 (NH).

Triraphis andropogonoides (Stedd.) E.Phillips, Z 4

schinensis Hack., S 2154 (PRE), U 57 (NH).

CYNODONTEAE

Chloris gayana Kunth, S 2196 (PRE), U 115 (NH).

virgata Sw., S 2187 (PRE).

Cynodon dactylon (L.) Pers., S 2149 (PRE), U 29 (NH).

Eustachys paspaloides (Vahl) Lanza & Mattei, S 2133 (PRE), U 42 (NH).

Peroxis patens Gand., S 2169 (PRE), U 32 (NH).

PANICOIDEAE

Acroceras macrum Stapf, B 1708

***Allotrospus papillosa Clayton, S 2166 (PRE), U 109 (NH).

Brachiaria chusqueoides (Hack.) Clayton, S 2147 (PRE), U 55 (NH).

deflexa (Schumach.) C.E.Hubb. ex Robyns, Ma 102 (LUAI), H 3047

humidicola (Rendle) Schweick., S 2157 (PRE).

ngrepidota (Ficalho & Hiern) Stapf, S 2192 (PRE), U 95 (NH).
Cenchrus
*brownii Roem. & Schult., S 2129 (PRE)
ciliaris L., S 2199 (PRE), U 111 (NH)

Digitaria
argyrotricha (Andersson) Chiov., S 2163 (PRE), U 50 (NH)
ciliaris (Retz.) Koeler, MB 541
debilis (Desf.) Willd., Ma 103 (LUAI), My 1088

tenalesis Stent, U 21 (NH)

Echinochloa
colina (L) Link, S 2195 (PRE), U 118 (NH)
holubii (Stapf) Stapf, Z 12
pyramidalis (Lam.) Hitchc. & Chase, H 3057

Eriochloa meyeriana (Nees) Pilg. subsp. meyeriana, N 382 (UZL), U 116 (NH)

Melinis repens (Willd.) Zizka
subsp. grandiflora (Hochst.) Zizka, U 90 (NH)
subsp. repens, S 2198 (PRE), U 52 (NH)

Oplismenus hirtellus (L.) P.Beauv., Z 5

Panicum
coloratum L. var. coloratum, N 385 (UZL)
deustum Thunb., S 2139 (PRE), U 108 (NH)
genuflexum Stapf, Z 15
glandulopaniculatum Renzoive, B 1196
heterostachyum Hack., Z 6
infestum Peters, Z 9
kalaharense Mees, S 2184 (PRE)
laticomum Nees, Z 8
maximum Jacq., S 2179 (PRE), U 92 (NH)
pleianthum Peters, S 2143 (PRE), U 49 (NH)

Paspalum scrobiculatum L., V 38

Sacciolepis curvata (L.) Chase, S 2150 (PRE), U 64 (NH)

Setaria
incassata (Hochst) Hack., S 2194 (PRE), U 114 (NH)
megaphylla (Steud.) T.Durand & Schinz, S 2160 (PRE)
phacelata (Schumach.) Moss var. sericea (Stapf) Clayton, S 2132 (PRE), U 73 (NH)

Stenotaphrum dimidiatum (L) Brongn., S 2108 (PRE)

Tricholaena monachne (Trin.) Stapf & C.E.Hubb., Z 10

Urochloa mosambicensis (Hack.) Dandy, S 2138 (PRE), U 96 (NH)

ARUNDINELLEAE
Tristachya nodiglumis K.Schum., S 2193 (PRE), U 105 (NH)

ANDROPOGONEAE
Andropogon
eucomus Nees, S 2155 (PRE), U 72 (NH)
gayanus Kunth var. polycladus (Hack.) Clayton, S 2168 (PRE), U 84 (NH)

Bothriochloa insculpta (A.Rich.) A.Camus., Z 7
*Cox lacryma-jobi L., My 1235

Cymbopogon
excavatus (Hochst) Stapf ex Bartt Davy, S 2138 (PRE), U 62 (NH)
nardus (L) Rendle, S 2197 (PRE), U 117 (NH)
pospischilii (K.Schum.) C.E. Hubb., PP 1068

Diheteropogon amplexentris (Nees) Clayton, MD 3942
Elionurus muticus (Spreng.) Kuntze, S 2191 (PRE), U 102 (NH)
Hemarthria allissima (Poir) Stapf & C.E.Hubb., MC 1163

Hyperthelia dissoluta (Nees ex Studt) Clayton, S 2118 (PRE), U 41 (NH)

Imperata cylindrica (L) Raeusch., S 2117 (PRE), U 16 (NH)

Ischaemum fasciculatum Bron., S 2121 (PRE), U 78 (NH)

Monocymbium ceresiiforme (Nees) Stapf, MC 1161

Sorghastrum stipoides (Kunth) Nash, B 1579
Sorghum bicolor (L) Moench subs. arundinaceum (Desv.) De Wet & Harlan, S 2198 (PRE), U 113 (NH)

Theseda triandra Forsk., S 2135 (PRE), U 39 (NH)

Trachypogon spicatus (L.) Kunze, S 2165 (PRE), U 44 (NH)

Urelytrum agropyroides (Hack.) Hack., S 2167 (PRE), U 37 (NH)